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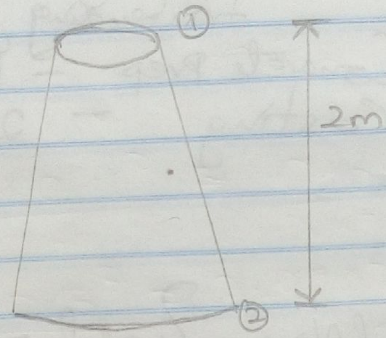
19/ENG03/032
CIVIL ENGINEERING
ENG214.

1. $V_1 = 5m/s$



$V_2 = 2m/s$

$$\text{Loss of head } (h) = \frac{0.35(V_1 - V_2)^2}{2g}$$

$$h = \frac{0.35(5 - 2)^2}{2g} = \frac{3.15}{19.62}$$

$h = 0.16m$

$h = h_1 - h_2$

$$h_1 = \frac{P_1}{w} + \frac{V_1^2}{2g} + Z_1$$

$\frac{P_1}{w} = 2.5m$, $V_1 = 5m/s$ $Z_1 = 2m$

$$h_2 = \frac{P_2}{w} + \frac{V_2^2}{2g} + Z_2$$

$\frac{P_2}{w} = ?$, $V_2 = 2m/s$, $Z_2 = 0m$

$$\therefore h = \left[\frac{P_1}{w} + \frac{V_1^2}{2g} + Z_1\right] - \left[\frac{P_2}{w} + \frac{V_2^2}{2g} + Z_2\right]$$

$$0.16 = (2.5 + 1.27 + 2) - \left(\frac{P_2}{w} + 0.204 + 0\right)$$

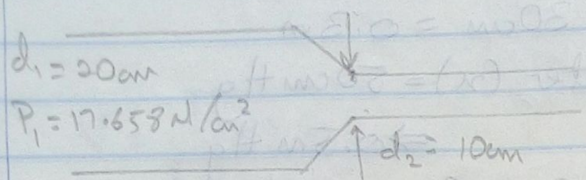
$$0.16 = 5.77 - \frac{P_2}{w} - 0.204$$

$$\frac{P_2}{w} = 5.77 - 0.16 - 0.204$$

$$\frac{P_2}{w} = 5.406m$$

2. $d_1 = 20cm = 0.2$, Pressure head at throat $= -30\ cmHg$

$C_d = 0.98$



$d_1 = 20cm = 0.2m$

$A_1 = \frac{\pi \times 0.2^2}{4} = 0.0314 m^2$

$d_2 = 10cm = 0.1m$

$A_2 = \frac{\pi \times 0.1^2}{4} = 0.00785 m^2$

$P_1 = 17.658 N/cm^2 \Rightarrow 17.658 \times 10^4 N/m^2$

Pressure head at inlet $\Rightarrow \frac{P_1}{w} = \frac{17.658 \times 10^4}{1000 \times 9.81}$

$= 18m$

Pressure head at throat = manometer reading × S.g of mercury

Manometer reading $= -30\ cmHg$

$\Rightarrow -0.3\ mHg$

S.g of mercury = 13.6

$\therefore \frac{P_2}{w} = -0.3 \times 13.6$

$= -4.08m$

Differential head $(h) = \frac{P_1}{w} - \frac{P_2}{w}$

$= 18 - (-4.08) = 22.08m$

$Q = C_d A_1 A_2 \sqrt{\frac{2gh}{A_1^2 - A_2^2}}$

$Q = 0.98 \times 0.0314 \times 0.00785 \times \sqrt{\frac{2 \times 9.81 \times 22.08}{0.0314^2 - 0.00785^2}}$

$= 2.416 \times 10^{-4} \times \sqrt{\frac{433.21}{9.243 \times 10^{-4}}}$

$= 2.416 \times 10^{-4} \times 684.72$

$Q = 0.165\ m^3/s$

3. diameter of orifice(d_0) = 15 cm = 0.15 m
diameter of pipe (d_1) = 30 cm = 0.3 m
pressure difference manometer (x) = 50 cm Hg
⇒ 0.5 m Hg

Q = ? , s.g of oil = 0.9 , $C_d = 0.64$

$A_0 = \frac{\pi \times 0.15^2}{4} = 0.0177 m^2$

$A_1 = \frac{\pi \times 0.3^2}{4} = 0.0707 m^2$

Differential head (h) = $x\left[\frac{S.g\ mercury}{S.g\ oil} - 1\right]$

$= 0.5\left[\frac{13.6}{0.9} - 1\right]$

$= 7.06 m$

Rate of flow through an orifice meter $Q = C_d A_0 A_1 \sqrt{\frac{2gh}{A_1^2 - A_0^2}}$

$C_d = 0.64$

$Q = 0.64 \times 0.0177 \times 0.0707 \times \sqrt{\frac{2 \times 9.81 \times 7.06}{0.0707^2 - 0.0177^2}}$

$= 8.009 \times 10^{-4} \times \sqrt{\frac{138.5172}{4.6852 \times 10^{-3}}}$

$= 8.009 \times 10^{-4} \times \sqrt{29564.84}$

$Q = 0.137 m^3/s$

4. Since no value for coefficient of pitot tube (C_v) is given, we use formula for theoretical velocity.

$V = \sqrt{2gh}$

Difference of mercury level (x) = 170 mm Hg = 0.17 m Hg
S.g of mercury = 13.6
S.g of sea water = 1.026
Difference of seawater level (h) = $x\left[\frac{S.g\ mercury}{S.g\ sea\ water} - 1\right]$

$= 0.17 \times \left[\frac{13.6}{1.026} - 1\right] = 2.08$ m of Sea water

$\therefore V = \sqrt{2 \times 9.81 \times 2.08}$

$V = \sqrt{40.8096}$

$V = 6.39$ m/s

5. Actual flow rate (Q_A) = 0.05 m^3/min ⇒ 8.33×10^{-4} m^3/s

ΔP = 15 bar = 15×10^5 N/m^2

Speed of rotation = 1700 rev/min ⇒ 28.33 rev/s

normal displacement = 10 cm^3/rev = 10^{-5} m^3/rev

Torque = 15 ~~Nm~~ Nm

i. Volumetric Efficiency = $\frac{\text{Actual flow rate}}{\text{Theoretical flow rate}} \times 100$

Theoretical flow rate (Q_T) = normal displacement × speed of rotation.

$= 28.33 \times 10^{-5}$

$= 2.833 \times 10^{-4}$ m^3/s

$\therefore$ Volumetric Efficiency = $\frac{8.33 \times 10^{-4}}{2.833 \times 10^{-4}} \times 100$

$= 294.03$ %.

This value is obtained because actual flow rate >> than theoretical flow rate.

ii. Fluid Power (P_F) = $Q_A \cdot \Delta P$ ⟨Actual flow rate × change in pressure⟩

$P_F = (8.33 \times 10^{-4}) \times (15 \times 10^5)$

= 1249.5 Watts

= 1.249 KW

iii. Shaft Power = $T \cdot \omega$ ⟨Torque × angular speed (rad/sec)⟩

$T = 15$ Nm

$\omega = 2\pi N$ where N → speed of rotation.

$\omega = 2 \times \frac{22}{7} \times 28.33 = 178$ rad/sec

Shaft power = 15×178
$= 2670$ watts
$= 2.67$ kW

iv Overall Efficiency = $\frac{\text{Fluid Power}}{\text{Shaft Power}} \times 100$
$= \frac{1.249 \times 10^3}{2.67 \times 10^3} \times 100$
$= 46.78\%$

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